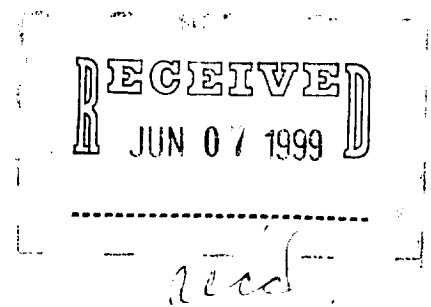


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**Preliminary Findings:
Issues in Surface Movement**

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The recent goals for this project have been:

1. To identify common surface movement challenges which affect the airlines and Air Traffic Control;
2. To map out possible solutions to these challenges;
3. To start generalizing about the information we are receiving so that major, abstract categories of challenges and potential solutions will begin to emerge.

In particular, there are several areas of opportunity which are beginning to emerge from the data, dealing with the need for:

1. Tools to support information exchange regarding priorities (both within an individual airline and between the ATC tower and airlines). Such priorities include both concerns affecting departure throughput as well as the ordering of departures to accommodate other airline considerations.
2. Planning tools to help ATC and airline Ramp staff deal with information about priorities;
3. Implementation of strategies to enable greater flexibility in queueing flights for departures;
4. Tools to provide better coordination and situation awareness

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during taxiing (within an airline, as well as between airlines and between the airlines and ATC);

5. Tools to support planning and to deal with the interactions between departures and arrivals.

Thus far, we have completed initial interviews and observations at three airlines (Delta, Northwest and TWA) and two ATC facilities (Detroit and St. Louis). Before we pursue any new activities, we would like to get some feedback. Enclosed are some of the things we have observed thus far. Obviously, there are differences between airlines and some of our notes may only apply to one airline's operation or one location. If you notice something which doesn't seem to apply to you, please let us know. We will call you in a couple of weeks to get your thoughts on the issues raised by these observations.

Initial Observations on Surface Movement

Below, we summarize some initial observations. They are organized as six challenges to surface movement and a parallel observation from another organization (correspondence from members of the RTCA Committee 191). The challenges include:

1. Maintaining Adequate Situation Awareness;
2. Reducing Taxi Time Delays;
3. Launching High Priority Flights in a Timely Fashion;
4. Sequencing Flights to Maximize Efficiency;
5. Improving Simulation Software for Surface Movement; and
6. Using Airport Resources Efficiently.

Challenge 1: Maintaining Adequate Situation Awareness - Observations at Atlanta

One of the issues that arose in our initial observations deals with problems that ramp control staff and flight crews sometimes have with maintaining situation awareness. Below, several key observations are included based on interviews and observations at Delta's Ramp Control facility in Atlanta.

Communication/Coordination/Cooperation Among Members of the Surface Movement "Team". There appears to be a tremendous amount of coordination and communication that must occur in order to create a smooth surface movement operation. As one Ramp Controller stated about his job, "It's all in the communications." Also critical is the cooperation between the different functional members of the team, which includes the different ramp tower personnel (e.g., gate coordinators, ramp controllers, FAA liaison, Ramp coordinator), gate agents, ground crew (e.g., supertug operators, wing walkers), pilots, and FAA tower personnel.

Following are examples of events that triggered arrival and departure delays and involved various members of the "team."

General Problem: Aircraft delayed in getting to (or out of) assigned gate.

Subproblem: Supertug not where it should be.

A plane was at the gate waiting for supertug to take it "off-line" and another plane was on the ramp waiting for that gate to open up. No one seemed to know where the supertug was; "Can't get a tug to be where we need it to be when we want it!" As a result there had to be a gate change for the waiting plane.

Questions:

- * How are the supertugs scheduled?
- * Who is responsible for their scheduling?
- * What are all the jobs the supertugs do?

Subproblem: Ramp tower not getting accurate information from gate agent re: plane occupying gate.

The plane in the gate had maintenance performed on it and another plane was ready to enter that gate and had entered the ramp; the Gate Agents told the Ramp Controller that it would only be a couple of minutes, but there was another communication from a Controller several minutes later, that maintenance was finished. (The ramp saw a ladder hooked to the plane so that information was not accurate). There was communication back and forth between the gate and controller and between the controller and pilot regarding the delay. (The conversation among Ramp personnel included: "can't get good information from below on what's happening at the gate -- ship's in, we're continually being told that maintenance is

done. Gate agents don't provide ramps with good information. They continually lie to us.")

A Ramp Controller called the gate on the regular telephone (He may not have wanted others to be able to listen in on the conversation via radio).

The gate keeper found another gate for the waiting plane.

Subproblem: Catering truck "dead" and blocking gate.

During a very busy push time of 9:00 a.m., food truck was at the gate and "dead". Maintenance had it up on blocks working on it. The plane was waiting to enter the gate. There was a lot of communication occurring between Controller, Ramp Maintenance Person, and Tower Coordinator. The Ramp Tower just wanted to get the truck towed away, but that didn't happen resulting in a lots of frustration. They had to find another gate for the waiting plane.

The aircraft was waiting to get into gate A19, and was blocking gates A17, A15, A13 so those planes couldn't pushback. Further, the planes waiting for A13 and A9 couldn't get in. They were all "holding out". The Ramp Controller said, "The only area I had working was down on the southside."

Subproblem: Gate and ground crew not at gate due to computer problem and didn't receive notice that plane had arrived.

Normally (when the computer system is working), when a plane reaches the outer marker (is "in range") a dot appears next to the gate that that flight is scheduled to arrive at (e.g., .A32 indicates the flight assigned to arrive into gate A32 has reached the outer marker). This "dotting" alerts the gate agent and ground crew to ready the gate for the arriving plane.

During my visit the computer communications were partially down so arrivals were not getting marked ("dotted") as having arrived, so the pilot had to wait for gate and ground personnel to get gate ready to receive arrival.

The "TV guys" are responsible for manual input of information and sometimes they make the error of entering that plane is at the gate when it isn't there yet. As a result, it doesn't show up in FIDS.

Subproblem: Ramp controller loses track of what flight is taxiing down ramp to gate.

"I hate it when I lose track." Said by Ramp Controller when he had lost track of a plane that was taxiing down ramp; he waited until the plane arrived at the gate so he could identify it.

"It's easier when its busy; It's hard to keep track when its not busy." Said by both

Ramp Controllers at different times.

Subproblem: The tug operator pushing a plane out of the gate didn't follow the Ramp Controller's instructions so it affected all traffic on the ramp because it had to avoid a jet blast.

Subproblem: The Pilot was not on the ramp frequency when Ramp Controller needed to contact the Pilot for instructions.

Sometimes the Ramp Controller wouldn't be able to 'raise' a pilot on the radio and would have to contact another pilot to ask the first pilot to switch frequencies so that the Ramp Controller could talk with them. (Note: We realize that some pilots have to work with multiple radio frequencies simultaneously.)

Subproblem: Plane cleared by ramp tower but delayed because groundcrew headset not working.

The Ground Crew's headset was not working so the ground person had to hold a face-to-face briefing with the pilot in the cockpit to communicate the hand signals that the ground person would use to guide the plane while pushing back. A face-to-face briefing in such a circumstance is an FAA procedural requirement

These events that contributed to delays in getting aircraft to their arrival gates suggest the following questions need to be asked:

- * Is there a need to provide better, up-to-date information on the status of the different parts of the operation?
- * Who needs what information when?
- * Does there need to be some sort of redundancy in the system so that the ground crew and gate agents know the status of an airplane (e.g., that it is on the ground) without relying on FIDS (e.g., a ground status display that displays what displays what planes are where at any given moment)?
- * Do we need a tool that will allow for dynamic information regarding the aircraft on the ground (e.g., where any given plane is at any given time)?
- * How is all the information needed by individual members of the surface movement team disseminated, i.e., by what means (e.g., radio, face-to-face communication, computer display, printer output, etc...)?
- * What are the cascading effects of a gate change?

Memory Burden. The Ramp Controller had to turn a plane around at the top of the ramp because he (Ramp Controller) couldn't remember what restrictions the FAA

had put on which runway. The ramp controller called the FAA to inquire about the restrictions.

Ramp controller to DL746: "I think I messed up sir. Stand by.....I pushed you the wrong way." He had called the FAA to inquire about whether they wanted all of the vectors out the North, saying that he couldn't remember.

There appears to be a great deal of information that seems to be "in the head" of the Ramp Controller. Further investigation should try to map out exactly what information is necessary for smooth operation of surface movement, and where that information can be found. If a great deal is "in the head" perhaps it would be appropriate to take some of that memory burden from the controller, representing the needed information in a display that is easily and readily accessible when the ramp controller needs it.

Wrong Ramp. In an 18-hour period it was observed that three pilots entered the wrong ramp upon arriving at the airport. The ramp controllers indicated that this is not an infrequent occurrence.

One of these occurrences was explained by the ramp controller as an inherent problem with the ACARS system that the pilots use: ACARS tells the pilot what gate the plane will be departing from next and the pilot assumes that it is the same gate that they are arriving into; However, sometimes the plane will spend the night at one gate and then be towed to a different gate where it will be departing from in the morning. Thus, on this particular occasion the pilot headed for the T-concourse (Ramp 1) (which was where the plane would be departing from in the morning) and then had to go to the B-Concourse (Ramp 2) to his assigned arrival gate

Some of the following questions need answering:

- * How frequently do such events occur?
- * What is the extent of the impact when such events occur?
- * Why are they occurring?
 - + Is it an incorrect/inaccurate understanding of ACARS?
 - + Is a lack of 'situation awareness'?
 - + Is it a lack of appropriate attention to where the pilot is at the airport?
 - + Is there a signage problem on the ramps?
 - + Is it inaccurate/inadequate communication between the ramp and the pilot?

Summary - Maintaining Adequate Situation Awareness

These examples illustrate the need for extensive communication between multiple groups of people all working toward a smooth surface operation. Given the extent

of the needed communications and the detail involved in them, there is a need both to ensure that the information is communicated effectively and maintained in such a way that the individuals who need that information are able to readily access it again in the event that they do not remember it when it is needed. This suggests that there is a need to thoroughly map out the many lines of communication, what information is needed by whom and at what time, and how it should be communicated in order to ensure appropriate awareness of that information by the recipient.

Challenge 2: Reduce Taxi Time Delays

Overview

One of the issues which continues to arise in discussions with both airline personnel and ATC is the need to accommodate their priorities. For the airlines, this means "maximizing the product" for their high yield flights. For ATC, it means handling departing planes as efficiently as possible. (The airlines view this latter goal as of central importance as well.) Both of these positions are described below along with the classes of solutions which have been suggested to accommodate them.

Example

When visiting TWA, we were told that an increase in average taxi time by one minute at this airport costs the airline an average of \$1,077,000. Thus, if all planes save a minute of taxi time, the airline saves \$1,077,000. Average departure taxi times at this airport in July 1997 were 21.9 minutes. Average arrival taxi times for the same month were 6.6 minutes. Delays at another hub were longer with 27.5 minutes for departures and 6.8 for arrivals during July 1997. These numbers were ascertained in an airline study of taxi time. Given this the Vice President of Operations suggested that,

"There is a need to reduce departure taxi times by 18 to 20 minutes on average."

He continued that the reasons these delays are so long are:

1. The airport is used to capacity much of the day.
2. The environment surrounding the airport causes a high number of missed approaches. When this happens a departure slot is lost.
3. Taxiing to the runway requires crossing another active runway.

Further, there were other issues which he believed made surface movement at this airport difficult. They included:

1. Gate constraints - no universal gates which fit any size plane.
2. Taxiway constraints - crossing active runways.
3. Land constraints - no room to build beyond airport boundaries.
4. Runway constraints - due to navigational aids function.
5. Schedule constraints - East-bound and West-bound banks.
6. Crossing traffic between bordering ATC centers.
7. Holding room for only 20 planes off-gate.
8. Crew changes - departure crew is often on arriving flight.

9. Air National Guard - moves a squadron at a time as opposed to one plane at a time which monopolizes the runway for some time.
10. Inconsistent policies from bordering ATC centers.

Thus, a very precise schedule at this airport is needed to accommodate the limited critical resources. He finished by saying, "There are two major sins at this airport. The first is being late. The other is being early." This comment reflects the critical nature of the interactions of arriving and departing flights.

Solution 1: Reduce Departure Delays by Using Information on Fix Saturation

The airline cited above is trying to predict routine taxi delays due to fix saturation. Fix saturation occurs when several flights with the same departure time wish to pass over the same fix or use the same heading. The first flight can depart quickly, but to ensure adequate separation between flights going over that fix, ATC will have to delay the remaining flights. Thus, they are not allowed to take off until ATC is sure that adequate radar separation will be maintained. Therefore, the amount of delay grows when a number of sequential flights wish to go over the same fix.

Once the airline is aware that a fix will be saturated and, therefore, they will experience delays for flights using that fix, they develop new flight plans which avoid the saturated fix. For instance, a Dispatcher planning a flight from St. Louis to Boston might have various flight plans to choose from. Suppose that Plan A goes over Fix A, and that Plan B goes over Fix B. If the Dispatcher knows that Fix A is saturated, and that he can expect to experience delays due to that saturation, he is more likely to choose Plan B which will provide a lower elapsed time. Thus, the airline may begin to aid the sequencing process prior to handing the flights off to ATC.

Another challenge is predicting and/or knowing in real time that a fix is saturated. This saturation may be due to changes in enroute traffic, overflights, or departing traffic for that day. In either event, this is another case which requires different solutions to address.

Solution 2: Reduce Departure Delays by Alleviating Runway Saturation

By noting times of day when the demand for runways is above its capacity, the airline can work with the schedule to try to distribute flights so that runway capacity is not exceeded. This airline looks at runway demand for both arriving and departing flights as they have no dedicated arrival and departure runways at this airport. Further, they have moved some high yield flights to other positions in the schedule to reduce the probability that they will have to compete for the runway with other lower yield flights.

Solution 3: Reduce Departure Delays by Improving Coordination Among Airlines.

There is clearly a problem at Detroit with regard to the coordination of surface movement among airlines. This problem can be traced to a lack of knowledge about each other's intentions (lack of coordination during planning) and about current surface traffic (real-time situation awareness).

This problem was illustrated by an incident observed during a visit there. The Ramp Tower, staffed by NWA personnel, controlled flights from NWA, Delta and TWA. American currently does not coordinate its ramp activities through the ramp tower. In the incident, American pushed a two engine narrow body aircraft onto the ramp without being aware that a NWA flight was already moving on the ramp. The ramp was dark and wet and so narrow that only one plane could move on it at any time. The outbound NWA flight slammed on his brakes to avoid a collision.

Discussions with the ramp controller in Detroit revealed that there had been other problems in the past where American left a plane deep in the ramp overnight and then towed it to a gate at the end of the ramp in the morning. The towing sometimes occurred during a big push time for the other planes in the ramp thus slowing departures.

Caveat 1: Need for Coordination between Airline and ATC

There may be a need for coordination between an airline and ATC when changing flight plans to reduce fix saturation. The example below describes an attempt by one airline to reroute their flights to avoid bad weather. The airline unintentionally chose a fix which caused many ATC conflicts. While this example revolves around SWAP routes, the Controller quoted below was concerned that similar problems are likely to occur if an airline attempts to reduce fix saturation without communicating first with ATC.

"Thunderstorms were moving into the area. Rather than using the standard SWAP routes, this airline tried to get as many planes out of the airport as possible by changing their flight plans to avoid the weather. We didn't recognize that the fix they were using was for an arrival corridor to ORD, and let the planes depart. Enroute, Chicago Center realized that the flights were heading for the arrival fix into ORD. They contacted the airline and rerouted the flights. The airline switched back to the arrival fix again. It got really ugly. After that the flights were rerouted to avoid the ORD arrival corridor."

Summary - Reducing Taxi Time Delays

The comments above emphasize the fact that critical resources, in this case space for planes once on the ground, are extremely limited. Additionally, the taxi time delays are a major source of expense for the airline and they are working on various solutions to reduce them. This site demonstrates that the "problems" associated with surface movement are rarely single in nature. Rather, there are multiple

constraints which interact to create a much more complex situation. Similarly, the solution for addressing these issues is not a single one either. Instead, there are several individual solutions each of which addresses a different aspect of the situation, whose incremental gains combine to provide an overall, composite improvement for the airline.

Challenge 3: Airlines are sometimes unable to launch high priority departures in a timely fashion.

Overview

Preliminary investigations suggest that there are two interacting problems that result in inefficiencies that make it difficult to give priority to important flights. The first is that information exchange among dispatch, ramp control and ATC tower staff is sometimes inadequate. Consequently, these personnel do not have the information necessary to set priorities for different flights. The second problem is that, even with adequate knowledge to set priorities, congestion affecting gates and taxiways may make it impossible to act upon these priorities.

Example:

A compelling example is provided by the following illustration from a bad weather day at Chicago O'Hare:

Chief Dispatcher: "This is August 20, 1996, 1935 Z. Detroit is ground stopped. I'm sitting on an airplane in Chicago trying to go to Washington. O'Hare is on ground stop, all eastbound departures have been stopped coming out of Chicago to the East Coast. As you can see, you've got a line of thunderstorms that extends from Ft. Wayne up to Buffalo. At 2010, Cleveland Center's traffic from Washington Center is rerouted until 23Z. At 2024, the Detroit ground stop is extended until 21 Z. 2027, Boston/New York traffic to O'Hare is rerouted. I believe the reroutes were up in through Canadian airspace if my memory serves me right. At 2056 Z, Detroit's ground stopped till 22 Z except for Aurora and Minneapolis Centers. Bear in mind that traffic is still sitting on the ground in Chicago and building up. 2021 Z, O'Hare eastbound traffic is rerouted until midnight Z. 2221 Z, Detroit is rerouted until midnight Z. 2226, O'Hare is ground stopped until 23 Z ...

The weather never really got to Chicago. The weather stayed basically [there] through the whole afternoon. It took me 4.5 hours to get from O'Hare to Dallas. I had an airplane sitting on the ground that was trying to get to Grand Rapids, and they would not let him go, mainly because he was backed up so far in the line, they couldn't get him to a taxiway so they could get him out of line to get to the end of the runway so he could take off. Because now Chicago was just about virtually gridlocked."

As stated above, in this example the problem was not the communication of priorities, rather it was an inability to act upon them. The airline knew that there were a number of flights that could be cleared to depart because the weather had not impacted their particular routes. Unfortunately, access to the runways needed for these flights was blocked by the gridlock

caused by other aircraft that could not depart because their routes were impacted by the weather.

Lack of Coordination Within an Airline

Proposals for moving toward "free flight" advocate that the airlines take on more responsibility for making decisions about launching and routing aircraft. The following example illustrates some of the challenges that must be dealt with to make such proposals viable. This example was a particularly bad day in Detroit, leaving passengers sitting in planes on taxiways for several hours.

The Ramp Controller mentioned that he had a hotline to the ATC tower and that they had built rapport over time. (He was also very sensitive to turf issues.) This rapport was partially built in a series of meetings following the snow storm on Palm Sunday two years ago. This incident was also referred to as "Bloody Sunday". Inbound aircraft were arriving on schedule, but an unexpected snow storm occurred. Snow changed to rain and ice and back to snow several times. There were de-icing issues with outbound aircraft as there were several inches of snow covered by ice and more inches of snow. It took much longer than usual to de-ice these planes. (De-icing takes place at the gate currently at this airport.) As a result, arriving planes waited to get to gates for several hours while the departing aircraft were repeatedly de-iced.

A series of meetings with the FAA ensued to see how such a situation could be avoided in the future. the airline asked whether a ground delay program or a ground stop could have been implemented to stop the flow of arriving aircraft. The FAA responded that they could not do that as ground delay programs are only instituted when the airport arrival rate (AAR) is decreased due to weather conditions. (The weather conditions did not preclude landing in this case.)

Since the FAA did not feel it was appropriate for them to implement a ground delay program in such a case, they suggested that the airline consider implementing a company-based ground delay program in the future. In this situation it would be the airline's responsibility to cancel or delay their own inbound aircraft when they realized this situation might occur.

Clearly, there are major issues here in terms of the need for better information exchange, planning tools and procedures for coordination within an airline, between airlines, and between the airlines and the FAA.

Inadequate Communication of Priorities

In other cases, not only is there a need for better methods to accommodate airline priorities, there is also a need for better information exchange to determine them.

Information Needs of Dispatch. Dispatchers have some knowledge of which flights are a higher priority than others, but have indicated that they need additional information about the status of departing flights while those flights are still on the ground. This additional information concerns the current status of the flight (baggage on, ready to push, etc.) This would enable them to alert the appropriate individuals, either Ramp Control (or at some facilities, the ATC tower directly) , in those cases where a flight that is a priority from their perspective is not "on schedule."

Dispatchers also discussed how a more precise surface movement operation that takes into account flight priorities could help accommodate certain airspace constraints. For instance, dispatchers stated that at times it is critical that a flight be at a particular point in the airspace at a specific time:

"If we have to make a slot time over Alaska for a Russian route, we don't want to leave early."

Thus, dispatchers feel that:

1. They have information relevant to the prioritization of flights for takeoff;
2. They do not currently have the information needed to determine when there is a problem with a high priority flight, and consequently are not in a position to intervene to try to assure that such priorities are dealt with.

Information Needs of Ramp Control Personnel. An alternative or complementary solution to the problem of information exchange outlined above would be for dispatchers to communicate their knowledge of priorities to Ramp Control or the ATC tower, and to let those personnel determine whether any high priority flights are faced with possible delays. Interviews and observations of ramp control staff indicate that such airline priorities, as known by dispatchers, are not at present always communicated easily or effectively to Ramp Control. For instance, some flights are more important than other flights because these flights are big money makers for the airlines or because they are carrying critical cargo, as in the case of life guard flights (i.e., flights transporting transplant organs). When asked to list their information needs for understanding the status and priority of flights, Ramp Control personnel offered the following list as a starting point:

1. Where the crew is coming from for a departing flight.

This information allows the Ramp personnel to know whether the crew will be "on time" for their departing flight.

2. Maintenance information from mechanics on the ground--specifically when the diagnosis of a malfunction has been reached and the estimated time necessary to fix it.

This information would make it possible for Ramp personnel to make the decision of whether to have the passengers board and have the baggage be loaded while maintenance is being performed. It also helps them to plan proactively for actions they may need to take (e.g., whether to reassign the airplane that is scheduled to arrive into that gate into another gate or to have it held before entering the ramp).

3. Gateholds imposed by the ATC tower or air carriers.

A gatehold exists when aircraft are held at their gates for any variety of reasons, one of which is to transfer as many connecting passengers as possible from arriving flights that have been delayed. Gateholds thus impact not only the departing traffic but also the arriving traffic that may be waiting for a gate. In order for priority flights to be allowed to depart, Ramp Control personnel must know those priorities so that they take whatever action is required to get those flights out of the gate as soon as a hold is lifted and before moving those flights with lower priorities.

4. Delays, including ground delays and stops, for flights occupying gates and the reasons for those delays.

5. When an aircraft in airborne holding is expected to be given clearance to land.

6. Anticipated delays of incoming flights.

If Ramp personnel have information that an arriving flight has been delayed and will not arrive as scheduled, they are able to look at all of the possible implications of that delay which will vary with the state of the world at any given time (e.g., time of day, weather, regular or irregular operation). Examples of such implications are: How does this delayed arrival impact gate availability when the flight does arrive? Will a gate change be necessary? What is the impact of that late arrival on departing flights...how does it affect departing traffic on the ramp?...will departures have to be held in order to protect connecting passengers?

7. The status of the airport and its runways (e.g., when a runway will be plowed, or maintenance will be done on some portion of the airport), obtained from the airport authority.

This information allows Ramp personnel to make adjustments to how they

regularly plan the ramp traffic. For example they are able to adjust the gates available for arriving flights, and to reason about the direction in which departing flights should "push back" from the gate.

8. A list of runways that arriving flights will use in order to reason about managing those flights that are scheduled to depart.

SMA has been of considerable help with this problem where it has been undergoing test.

9. Whether particular flights that are expected to arrive early can afford to delay departure due to a stronger than forecast jet stream.

This information can be especially helpful if it allows for other priority flights to depart ahead of these flights while still ensuring that the long haul flight will arrive as scheduled.

10. Whether a plane will have to do airborne holding in order to get a transoceanic slot or for a particular altitude. (In these cases, it is more important that the plane be in the appropriate place at the right time to take advantage of the slot than to have a specific departure time.)

11. Whether a flight is a "life guard" flight. These flights receive ATC priority, but must often wait for an available gate if the ramp tower is not aware of its criticality.

12. Which of the airplanes in a departure rush are most critical for on time departure to satisfy company needs, and which aircraft are less critical.

Thus, there is a need for effective and efficient communication among AOCs, Ramp Control and the ATC Tower in order to ensure that the company's most important flights are given top priority with respect to surface movement.

Information Needs of ATC Tower Staff. When asked about airline priorities an ATC Operations Manager said that he would like to know which flights were the airline's high priorities but only if they were "no kidding priorities". At one point, the ATC tower had asked for a list of priority aircraft to help facilitate the airlines' needs. They were given a two-page list of flights that should receive high priority. He asked, "How can I ask my controllers to memorize all those flights? They have enough to do. If a flight has to be out -- no kidding -- then we'll get him out, but not just the ones they'd like out."

Summary - Airlines are sometimes unable to launch high priority departures in a timely fashion

Thus, either controllers need better tools to make it easier to handle priorities, or routine prioritization must be handled by the airline prior to pushing the planes from gates. With the latter solution there would be no apparent difference to the controller between higher priority flights and lower priority ones.

Challenge 4: Allow the ATC system to sequence flights on the ground in order to maximize efficiency.

A controller suggested that, at Detroit, there is a need to find a way to place planes in an order, prior to reaching the runway, so that a flight is not heading for a fix which is less than 15 degrees from the flight before it. He continued that airport throughput would be significantly increased consecutive airplanes were sequenced so that there was at least 20 degrees between their headings. He said, "If there are 20 degrees or more between the fixes, the faster the planes run [depart]. We can do 15 degrees, but 20 is better. If the headings are back-to-back [the same for two planes in a row] we need 1.5 minutes between planes. If they are sequenced in perfect order [greater than 20 degrees between the fixes for consecutive planes], we only need 45 seconds between planes." Thus, by ensuring that the planes departing in a bank are filed to different departure fixes, and ordering them such that no two consecutive planes are going to fixes within 20 degrees of one another, planes will depart faster, increasing runway efficiency.

Solution 1: Choose Gate Assignments to Facilitate Sequencing

The Controller suggested that one fast, easy, low-tech solution which would make his job easier was considering gate assignments with respect to the fixes the flights would head to first. For instance, if all west-bound flights could be handled in one portion of the terminal and all east-bound flights in another, many surface movement issues would cease to exist. By further considering when planes are likely to push given the schedule and when they should reach the runway from various gates a sequencing plan might be further developed.

Solution 2: Provide ATC with Tools to Perform Sequencing of Flights for Takeoff

When asked how sequencing was performed at the present time, the Controller said that it must be done manually given current technology. He suggested that if software tools or solutions to increase his flexibility, including Solutions 3 and 4 below, could be developed to help accommodate a sequencing scheme, he would be anxious to use them. He felt that a more efficient scheme would be possible with additional tools.

Solution 3: Pre-load Alternative Flight Plans into FMS

The Controller continued that it was too late to perform sequencing once planes were "in line" for the runway. This is partially due to the physical constraints of the airport which don't allow for easy re-ordering of planes. He asked whether FMS could be loaded with two Dispatcher approved viable routes and then the flight crew could be instructed by ATC that the preferred route is A based on fix saturation. Obviously, this scheme would make flight plans more flexible. He suggested that if this was not currently possible, it might be a worthy area to explore.

Solution 4: Find Ways to Move Planes on Ground to Accommodate Sequencing

Several ground maneuvers have been suggested to help sequence planes on the ground. Some of them are provided below. Again the reader should keep in mind that the efficacy of any one of these solutions has not yet been established. In fact, we have received contradictory opinions on some of these schemes to date.

Daisy Chain. The "token ring" (or "daisy chain") strategy would consist basically of a closed loop staging area for departing traffic. Departing flights waiting for access to a runway would park nose to tail in a circular fashion. Once ordered this way the planes could move in a circle until the high priority flight reached the end of the runway and could then depart. Obviously the implementation of this strategy will be affected by the physical constraints of the airport in question, but where it can be achieved, it could prevent the gridlock situation described by the dispatcher in the irregular operations example above, as well as facilitating the departure of high priority flights.

Intersection Takeoffs. One airline dispatcher, when discussing what might be done if he had more information about the status of the planes on the ground that were scheduled for departure, stated the following:

"I could have a flight do an intersection takeoff. You have to know where the plane is to do that."

This suggests the possibility of a form of queue, namely, a priority queue for flights that are already taxiing for takeoff. Under such a system, flights might be permitted to taxi as they currently are, but some metric would be used so that each flight would be given a priority number that could be compared to others for the same airline, also taxiing. If an opportunity occurred for a higher priority flight to "get in front" of a lower priority flight via an intersection takeoff, that opportunity could be taken.

Back Taxi. Another solution which was suggested by a Pilot was to back taxi the desired plane to the end of the runway and then take off. Also, there are a few airports which would not be able to accommodate this solution, including LGA and DC National. Modifications to their taxiways would have to be implemented to perform this maneuver.

Holding at Gate. Another possibility would be holding planes at the gate until it is time for them to get in line for departure. One of the potential issues with this solution is that arriving planes may not be able to unload passengers and crew if the gate is still occupied with a departing plane. This is especially important in the case where the departing crew is on the arriving plane. We discussed some of the problems with this solution in our second report.

Pull One Plane Around Another. One airport we visited had one plane remain on the taxiway or ramp and the plane to depart before it pass it to take its place in the queue ahead of it. This solution is troublesome if the space constraints of the ramp and taxiway do not allow easy execution of this maneuver.

Parallel Taxiways. In Dallas this particular need has been met by using two taxiways to feed the runways. All of the flights using one departure fix use one taxiway; the ones using the other fix use a second taxiway. The controller can then sequence the departures according to their departure fixes very easily.

Summary - Allow the ATC system to sequence flights on the ground in order to maximize efficiency

Again, the reader should keep in mind that these solutions for allowing greater flexibility are only preliminary. While they show promise, they have not been thoroughly verified at this point. Further, we have not had consensus from all the air traffic professionals that we have interviewed that they are all viable. In fact, we have had several contradictory statements regarding some of the solutions. This again underlines the fact that there is likely a need for multiple approaches to reduce surface movement issues and that their aggregate effect is what may provide the improvements the airlines desire.

Challenge 5: The need for Better Simulation Software to Consider Gate and Ramp Issues

Overview

Currently it is difficult to predict how changes in airport utilization or policies, such as gate assignments, will affect overall surface movement. As a result, it is possible that providing better predictive tools to indicate where small local changes made in one part of the airport may impact overall ground traffic patterns. The example below provides an illustration of that need.

Example:

One ATC Coordinator told us how she used simulation software to anticipate the effects of runway construction at a main hub. The construction would split a main runway into two shorter ones. The result was that the airport's capacity would increase as a result of this new runway configuration. This incident caused us to probe for more information about the use of this simulation and the way that it addressed other surface movement problems including gate and ramp constraints.

The ATC Coordinator told us that it was, "really just a fancy calculator" which made no suggestions for new configuration strategies. She did not believe that it would reason well about how best to use taxiways, ramps or gates.

Summary - The need for Better Simulation Software to Consider Gate and Ramp Issues

Given this, there seems to be a need for additional simulation or gaming software which would allow users to predict how a day's schedule could be expected to impact surface movements and would also suggest appropriate strategies for streamlining the operation.

Challenge 6: Airport Design/Utilization Strategies

Overview

A tremendous number of surface movement problems are related to the physical layout and constraints of a particular airport. These problems can be singular in nature as the layout of each airport is, to some degree, determined by the traffic and geographical characteristics of the area in which it is built. Given this, there is a need to use airport facilities in a way to maximize efficiency.

Example

The Ramp Controller at Detroit was unhappy that ATC often got planes in their departure order on the taxiway adjacent to the ramp. Some planes would be asked to hold until the plane which would depart before them had taxied past. As a result, they blocked the ramp and he could not move his other planes in and out. He suggested that his operation would work better if this sequencing occurred at another point on the airport or on the taxiway adjacent to the runway. This issue was addressed with ATC personnel at Detroit. Their perspective is provided below.

The ATC Operations Manager talked about how taxiways could be used effectively. One of his goals was to separate traffic to reduce cognitive complexity and the probability of accidents. Taxiway Tango, for instance, goes around the end of an active runway, but without intersecting with it. As a result, it is unlikely that ground incursions will occur between aircraft on Taxiway Tango and that runway. Further, completion of this runway reduced inbound delays by an average of 30 seconds per plane. This strategy both reduces taxi time and the probability of a runway incursion.

Further, when asked why departing aircraft were sequenced on the taxiway adjacent to the ramp and not the taxiway adjacent to the runway he gave the following answer. This airport has had several ground incursions including those that resulted in fatalities. This is partly a consequence of having a runway cross three other runways. It is also due to slips and mistakes of flight crews who mistake runways for taxiways. (There are many parallel runways and taxiways at this airport which would increase the probability of slips of this type.)

He suggested that arriving traffic had to use the taxiway adjacent to the runway to decrease the probability that they would mistake the runway for a taxiway. He felt that the probability that they would make this slip would be higher if they were heading the other direction on that taxiway. Thus, for safety, he felt that the east bound departures destined for the center runways had to be sequenced on the taxiway adjacent to the ramps so that the taxiway adjacent to the runway could be used for arriving aircraft. He continued that these issues would not exist if the east bound traffic could use the gates in center terminal area. He also suggested that the physical arrangement of this airport was similar to Kennedy.

At the current time, he said the "west ground controller survives. He must get his planes out of west ground to east ground as soon as possible. ... If you don't work west ground every day, you lose your edge here." He also quipped, "A controller's best friend is concrete."

Summary - Airport Design/Utilization Strategies

This example shows how constrained this airport is with respect to taxi issues on its west ground. Further, it shows how the distinct goals of ATC and Ramp Control cause each of them to prefer different utilization of the taxiway adjacent to the ramps in west ground. This suggests that utilization strategies must be developed with input from both groups to ensure that all needs and goals are considered.

Correspondence from Members of the RTCA Committee 191

Phil Smith is a member of the RTCA Committee 191 which has begun to collect some information on departures. Below is a sample of what they have started to do, and which may be useful as it is relevant to this project. In a previous report of ours it was emphasized that de-icing was an important surface movement issue. This e-mail correspondence supports that earlier statement.

The following passages are input from an airline Dispatcher as part of RTCA Committee 191. The first section is an e-mail message which he sent to the rest of the committee. The second is a colleague's response.

Initial E-mail Message:

If, at a given airport, aircraft routinely push back and take off in a narrow range of acceptable taxi times it is probably not worth investing in a mechanism to determine and express airline departure priorities. However at some airports (e.g. hubs) where large numbers of aircraft push back at the same time or under conditions of severe departure rate constraint (e.g. out bound de-icing) the ability to determine the order of takeoff might be of value to the operator.

In general that scheme that which produces the greatest number of departures in the shortest time is the most desirable for all operators. However when an operator has several flights as possible candidates for the same take off time there may be circumstances where an earlier take off time for one flight is more important than another.

Examples of conditions that might induce a decision for priority departure are:

- 1) The flight is destined to an airport with curfew or closure problems.
- 2) A delayed departure would cause a secondary downline delay due to awaiting aircraft or crew.
- 3) A delayed departure would cause downline passenger misconnections.
- 4) A delayed departure would cause reduced crew rest and would create secondary delay the next day.

The most constrained situation is the outbound deicing scenario where several aircraft might be ready for gate departure at the same [time] but their delivery to the departure runway might be distributed over hours. In this case departure or runway ready time slots may be issued to the airline based on number of scheduled departures. This [is] similar to the issuance of

CTAs under a CDM GDP [Ground Delay Program]. It is then up to the airline to determine which flights should be delayed, canceled and assigned to slots. The airline is responsible for providing an aircraft at the issued runway ready time. In this paradigm slots are rationed by some impartial system and priority is express[ed] by the airline assigning flights to slots.

I believe the reason why this is not a common practice today is that outbound deicing is seen as a "local" airport problem and slot allocation is determined by various entities using different methods across the country. With the GDP the controlling authority is centralized (ATCSCC) and so a consistent method and interface can be designed.

In a less constrained environment such as normal hub departure banks, a numerical value could be assigned by the operator to each flight as it departs the gate and sent to ATC for consideration in the overall departure scheme.

Response:

R's note [above] brings this group to the other 50% of airport activity that we currently do not touch: aircraft departures.

I agree with the note completely, but think we must complete one (small simple) step before we can examine this problem. We need to have a good picture of all planned departure activity.

This information exists in the ETMS data base, but as yet airlines do not have ready access to it. While in theory we could subscribe to all airports shown in the FSM Data Collector, we still could not identify 100% of all departures.

However, if Volpe were to sort its data base on departure airport, we could then (optionally) subscribe to a second file from each hub station: a departure file. The AOCnet should have the bandwidth to easily carry this additional traffic.

I actually have wanted this information for a long time. It will allow us to begin to balance departure traffic over departure fixes in something close to real time.

R's letter identifies a 2nd important use for departure data. Is this important enough to have Volpe work on a departure file and put the additional traffic on the AOCnet?

Summary - Correspondence from Members of the RTCA Committee 191

Again, this correspondence emphasizes the complex nature of surface movement and the multitude of potential issues which may arise and compound individual

problems into substantial ones down line. Given this, it is important to minimize problems at any point they occur, potentially by multiple means. Further, this correspondence is very consistent with other observations and with emphasis on the implications of de-icing in surface movement operations.

Overall Summary

The first generalization from the materials reported here must be that there is probably no simplistic or singular solution to the surface movement problem. The resolution of the problem will, however, clearly depend on providing better means of communication among air traffic control, airline operations centers, and ramp control, as well as providing them with real-time and post-operations analyses tools to assist in developing and implementing plans to improve surface movement. Learning what needs to be known, by whom, under what circumstances, and how it should be provided must be the central focus of further data collection if these solutions are to be designed to meet the needs of airlines and ATC.